



# Generating Satellite Climate Data Record over Canadian landmass

**R. Latifovic, A. Trishchenko,  
J. Chen, B. Park, R. Fernandes, D. Pouliot, K. Khlopenkov,  
J. Cihlar, C. Ungureanu**

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The objective of NRCan/ESS Program “Reducing Canada’s Vulnerability to Climate Change” (RCVCC) is to contribute to the understanding of climate variability and change in order to enhance society’s ability to plan and respond.





## Earth Science for National Action on Climate Change

### **Objective :**

**Project is focused on the synthesis products used by national process (Joint Ministers) & Intergovernmental Panel on Climate Change**

### **Project activities**

- 1) Radiation budget
- 2) Satellite records for CC
- 3) Ecosystem modeling
- 4) Water resources and vegetation dynamics
- 5) Cryosphere
- 6) Coastal zone





Long-term observations sustained over decades are a critical first-step in providing the climate data necessary for scientists, decision makers and stakeholders to make adaptive choices that could improve resilience to climate change and vulnerability, as well as maintain economic vitality.

## CDRs – Climate data records

Time series of measurements of sufficient length, **consistency and continuity** to determine climate variability and change. (NRC, 2004)

**FCDRs** – Fundamental climate data record.  
Calibrated and quality-controlled sensor data that **have been improved over time.**

**TCDRs** – Thematic climate data record.  
Geophysical variable derived from the FCDRs such as surface temperature and cloud fraction.





## Why do we need CDRs ?



TIME SERIES 1980 – 2005

### Changes in vegetation phenology

- Minimal, Maximal, Mean NDVI
- Amplitude in NDVI
- Total length of the growing season
- Fraction of growing season in green up
- Rate of green up
- Rate of senescence
- Integrated NDVI, green up, senescence, growing season

### Changes in surface characteristic

- Winter summer albedo
- Minimal, maximal surface temperature
- Diurnal surface temperature cycle
- Snow cover
- Land cover and land cover change
- Leaf Area Index

### Changes in water characteristic

- Lake surface temperature
- Diurnal lake surface temperature cycle
- Ice brake-up

### Radiation

Statistics on cloud cover

### Trend

NDVI  
LAI  
Air\_Temperature  
Radiation  
Precipitation  
Snow  
Lake temperature  
Forest fire

### Pattern

Forest fire – NDVI-Air\_Temp-Radiation-Precipitation-Snow-Cloud

Drought – NDVI-Air\_Temp-Radiation-Precipitation-Snow-Cloud

#Traffic Accidents- Air\_Temp-Precipitation-Snow-Cloud

Household -Energy Consumption

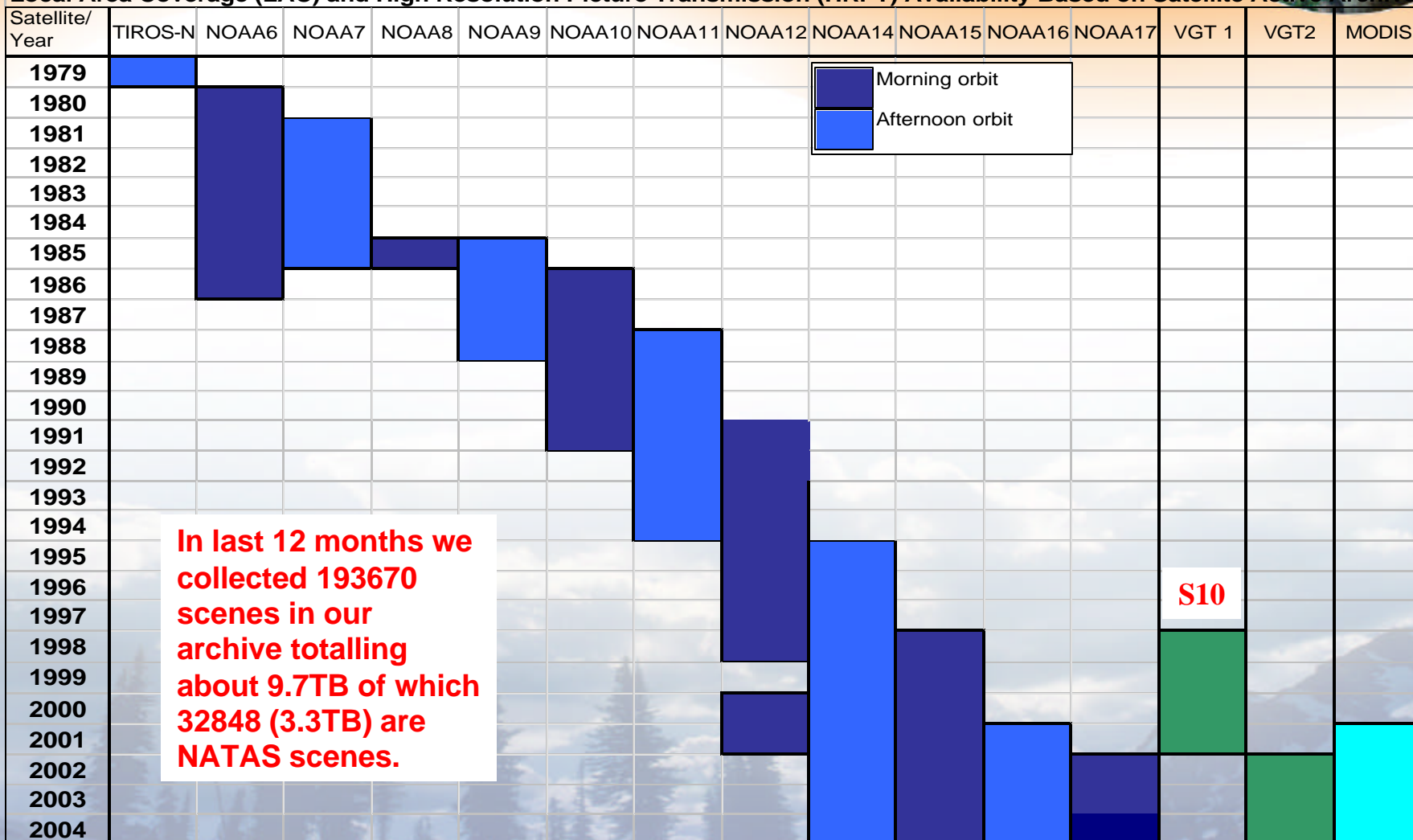
Sever weather events

## Models

# Satellite data



Local Area Coverage (LAC) and High Resolution Picture Transmission (HRPT) Availability Based on Satellite Active Archive





## Satellite CDRs unique characteristic

- Long term commitment to data collection and analysis.
- The need for **continual calibration, validation and algorithm refinement** i.e. monitoring performance of multiple observing platforms for long-term applications.
- Periodic reprocessing and reanalysis to improve error identification and reduce uncertainties.
- The need for significant computational resources for processing, archiving and timely access to data and metadata.



## Source of inconsistency in long-term satellite records

- Different atmospheric condition during data acquisition.
- Imperfect image navigation i.e. georeferencing and resampling (variable pixel size).
- BRDF effect due to variable viewing geometry.
- Sensor and cross-sensor calibration (SRF, PSF).
- Noise in internal calibration data (IR).
- Variable illumination condition due to satellite orbit drift i.e. change in equatorial crossing time.





**(AVHRR Processing System)**

**Data ingest:**

HRPT all formats, NATAS

Internal calibration data analysis and refinement

**Georeferencing**

Brower orbit model, TBUS archive 1983-2004, chip image data

Winter, summer day and night time orbit georeferencing and resampling

**Compositing**

Include radiometric, acquisition geometry and georeferencing accuracy criteria

**(VGT Processing System)**

**Post-seasonal data correction**

Calibration and recalibration

Atmospheric correction using time dependent atmospheric conditions

BRDF normalization

Cloud screening

**Data analysis**

Seasonal profile analysis

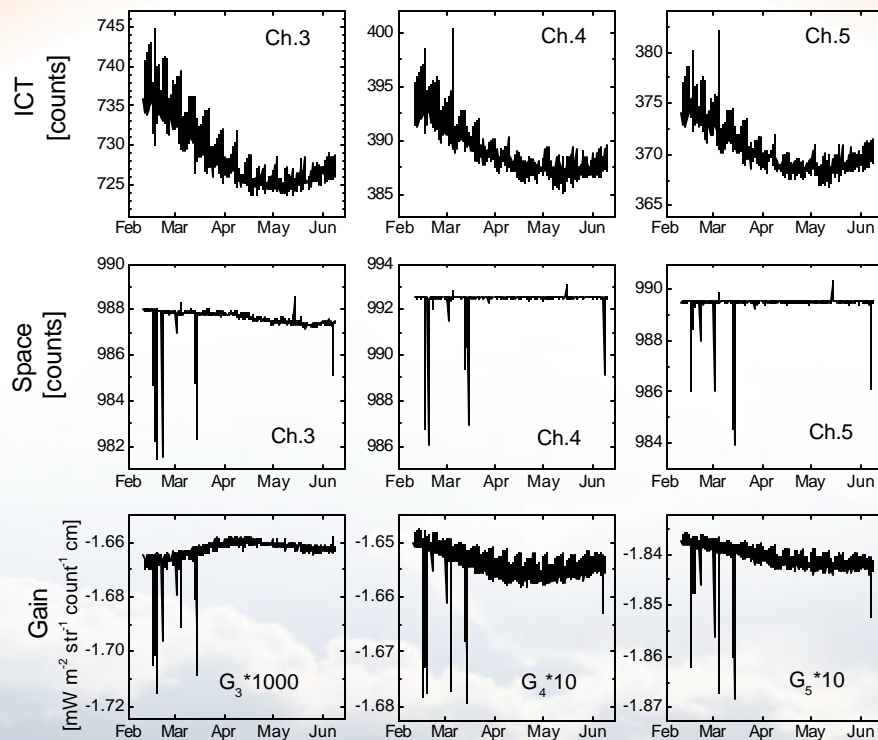
Time series



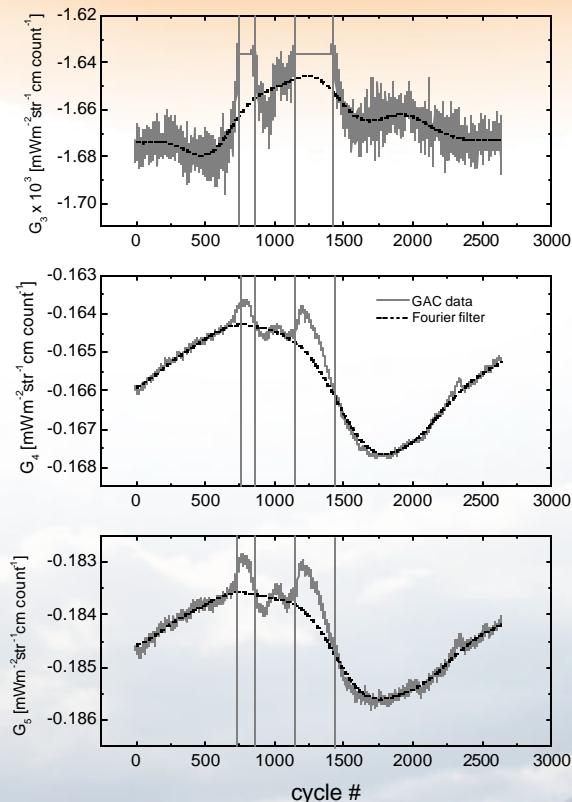


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NOAA-14 2000 DOY 305



**There are various unwanted fluctuations in thermal calibration data that can not be removed by standard quality control procedures and require robust techniques to be used**





## Inter-Comparison of Large Scale Optical Sensors

### Spectral response functions

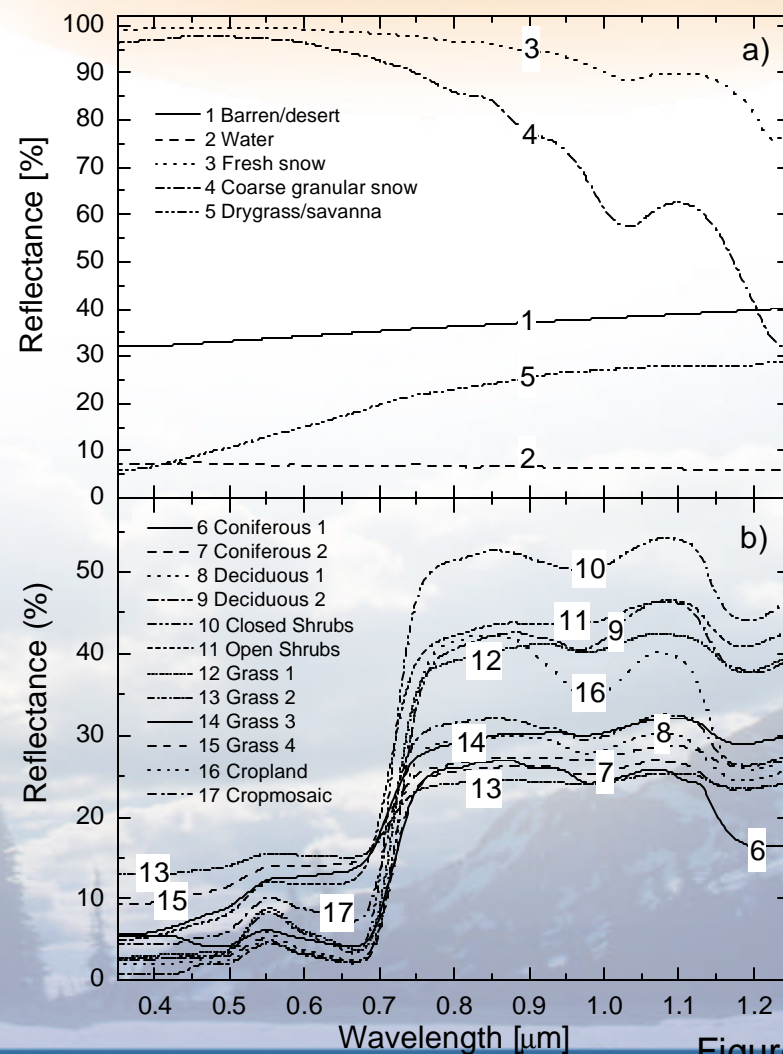
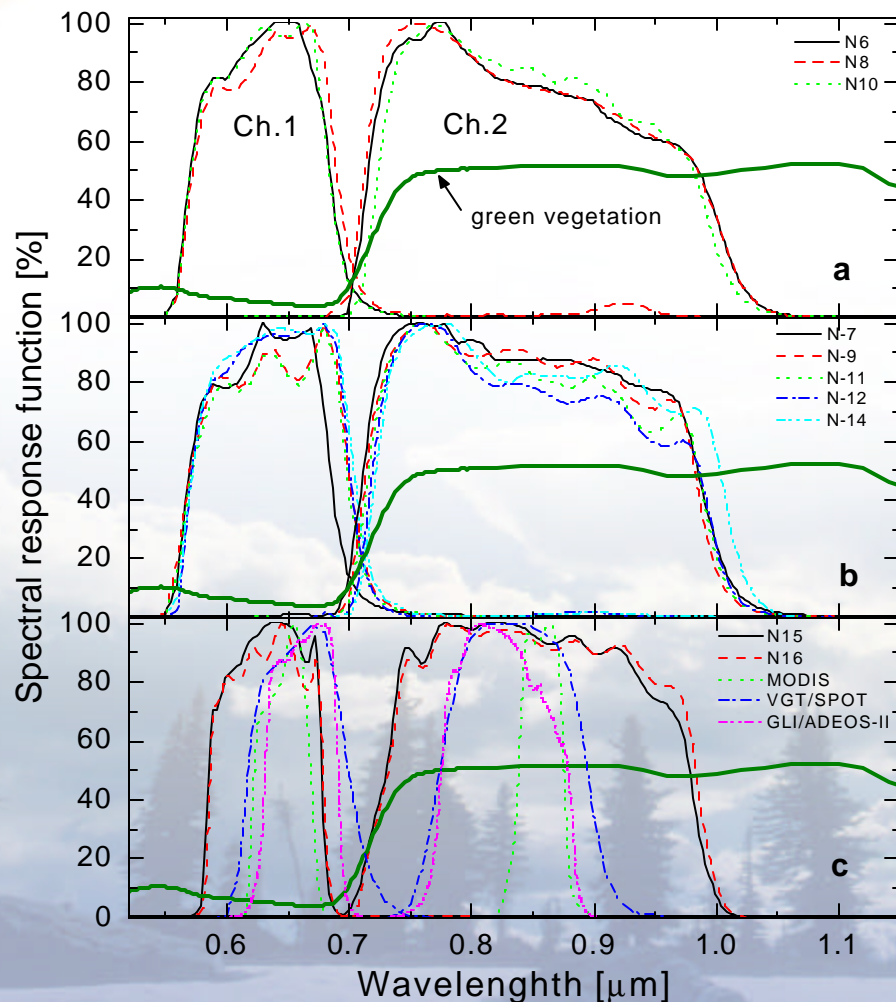
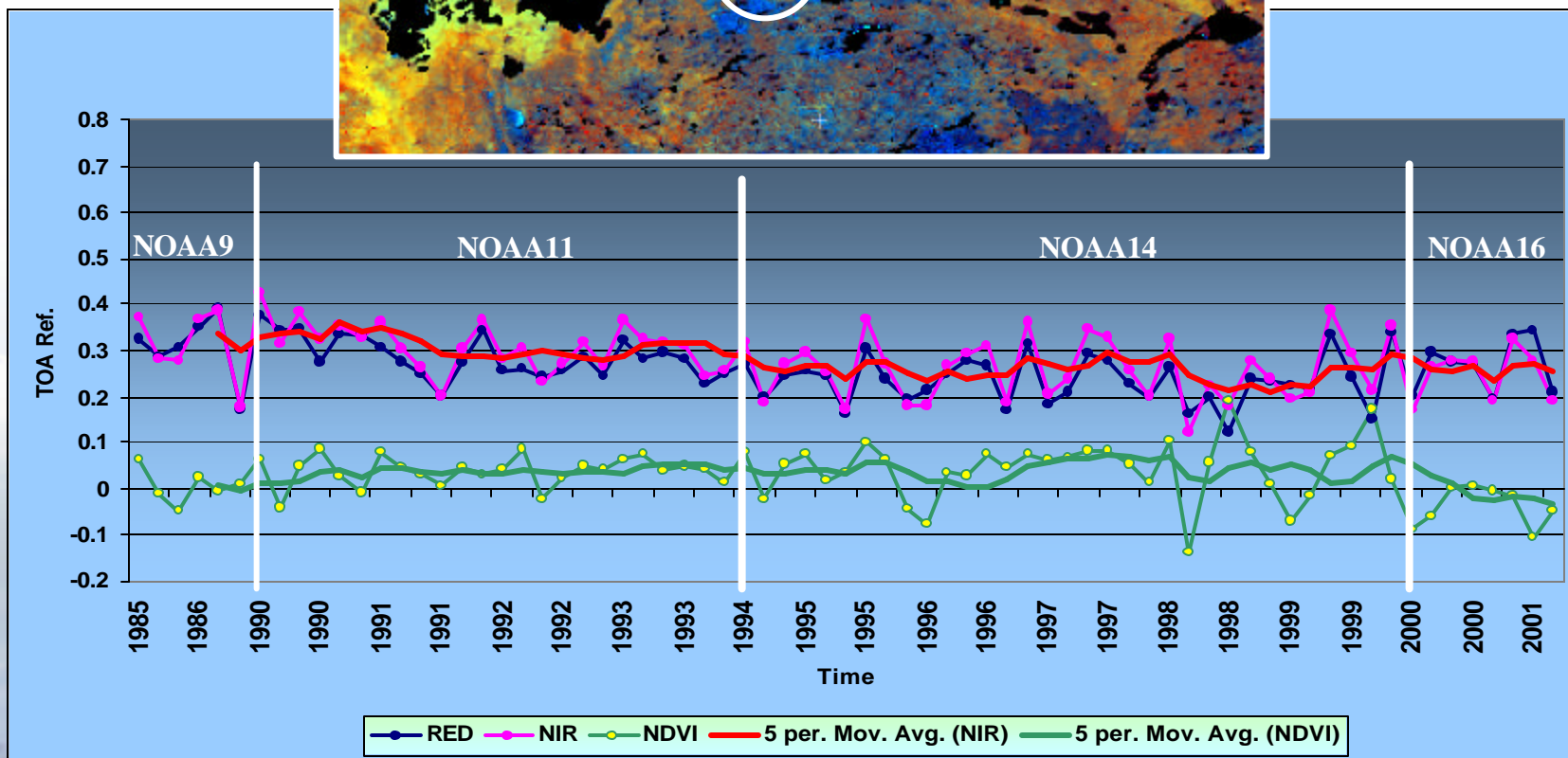
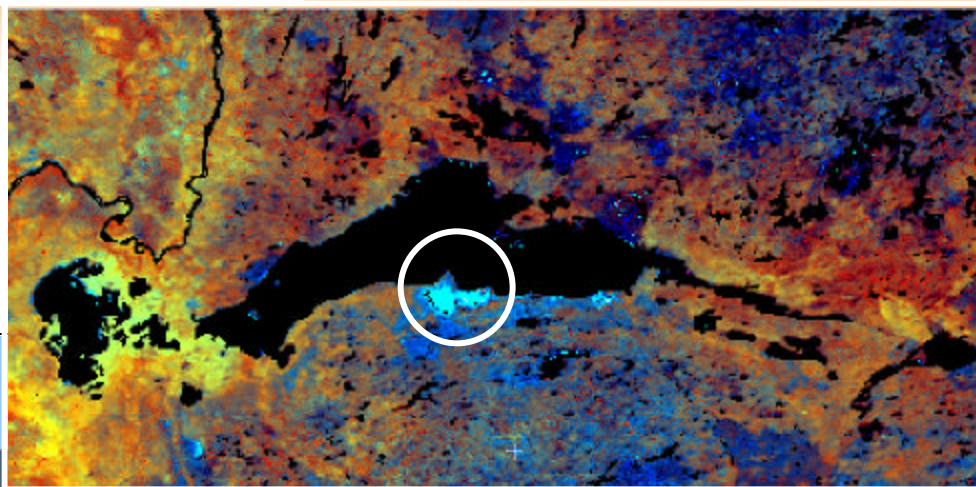


Figure 2







CCRS Calibration Coefficients  
Teillet, P. & Fedosejev, G.

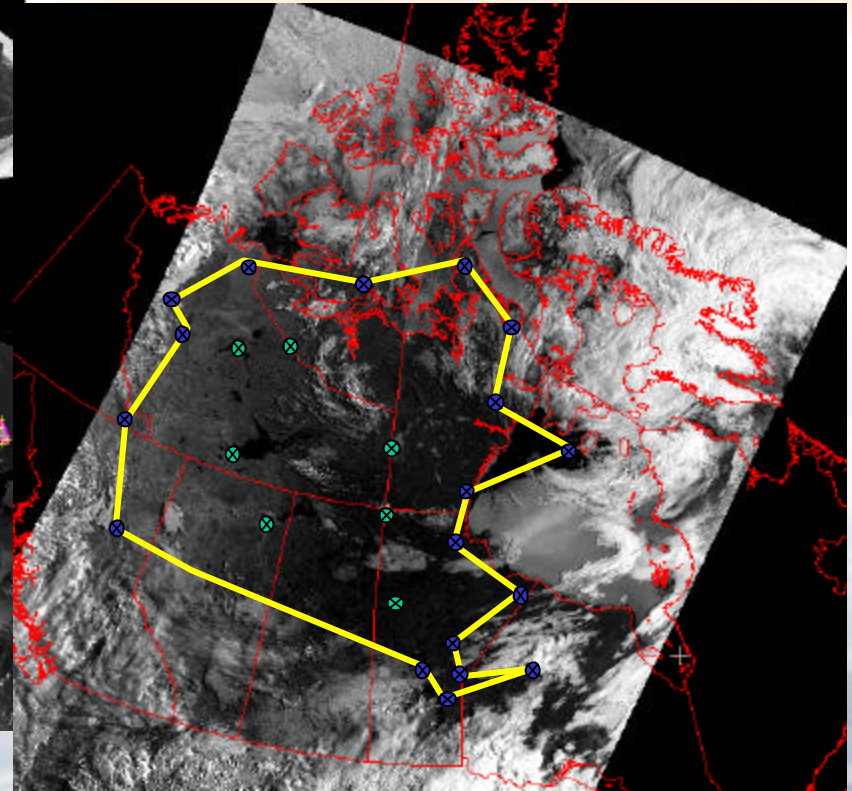
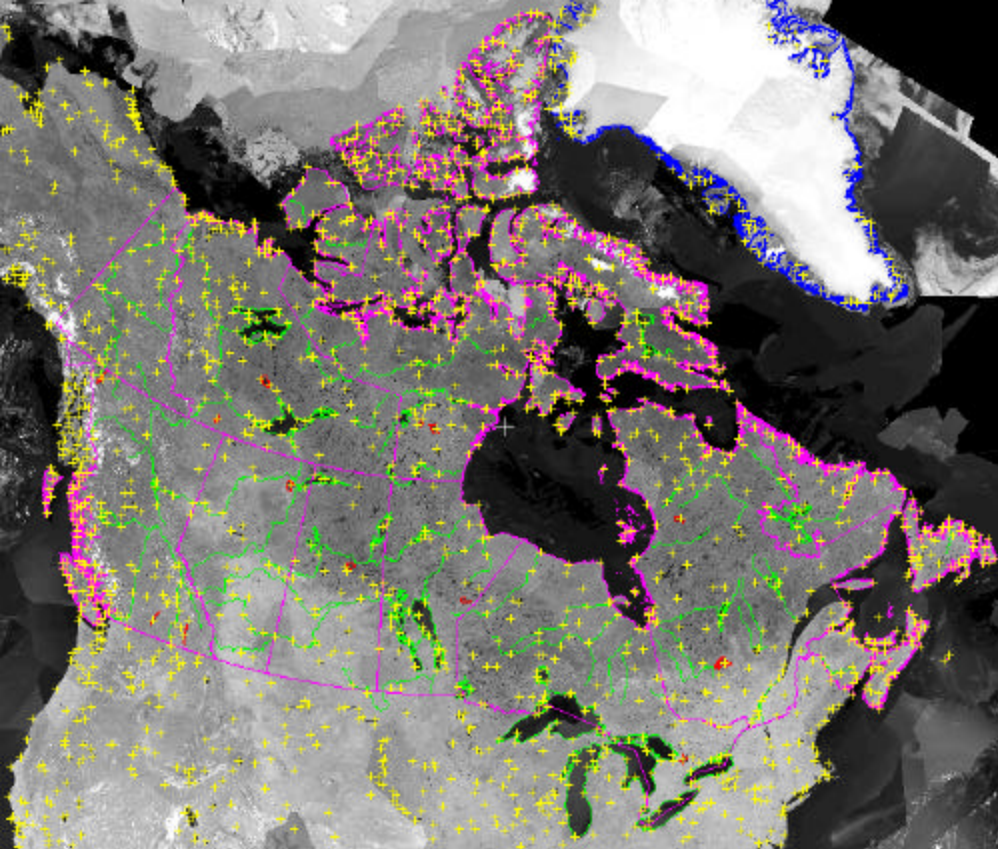


Natural Resources  
Canada

Ressources nat  
Canada







## Georeferencing

- Orbit model; TBUS (1983 – 2004)
- GCP; chip matching

Georeferencing accuracy criteria



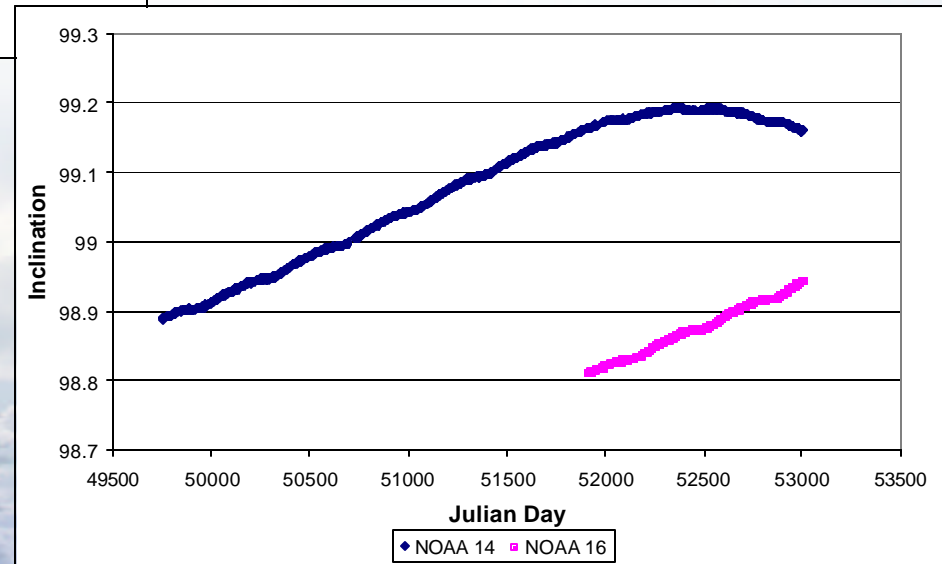
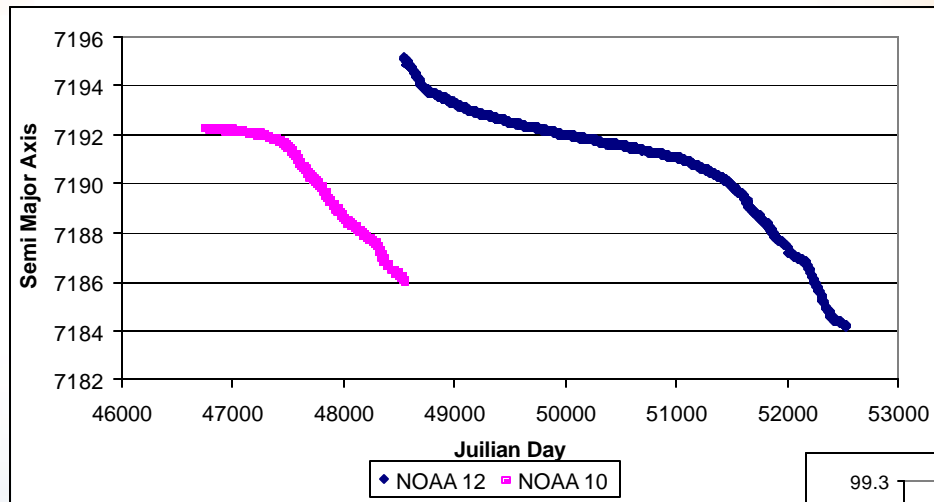


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### TBUS data analysis



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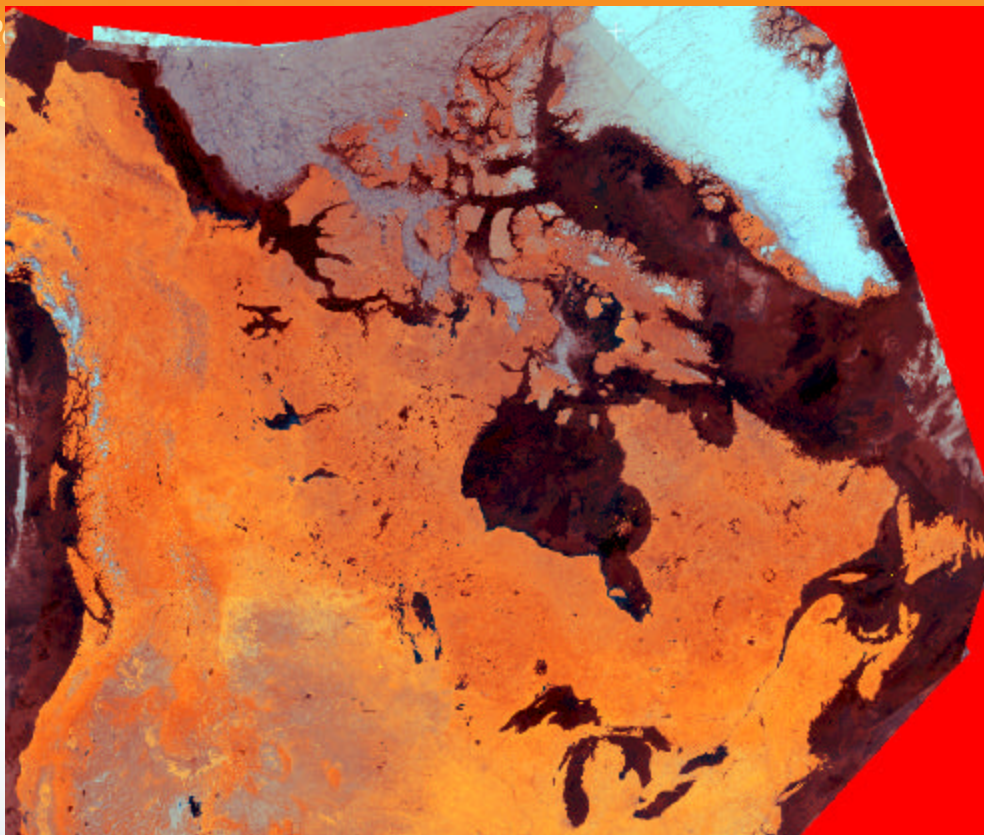
Ressources naturelles  
Canada

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## Compositing



Monthly composites  
of NOAA11  
August of 1990

MinVIS & VZ



MinVIS&MaxNDVI&VZ



MaxNDVI & VZ



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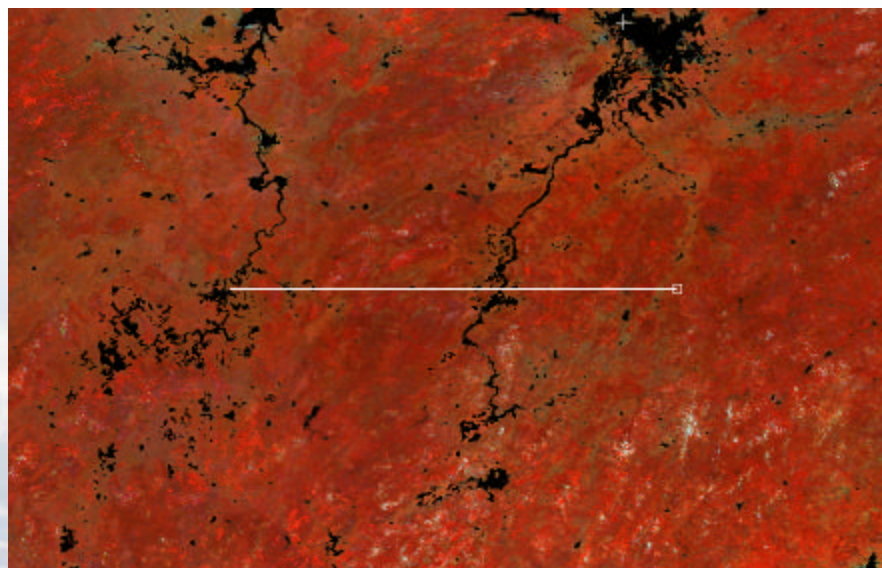
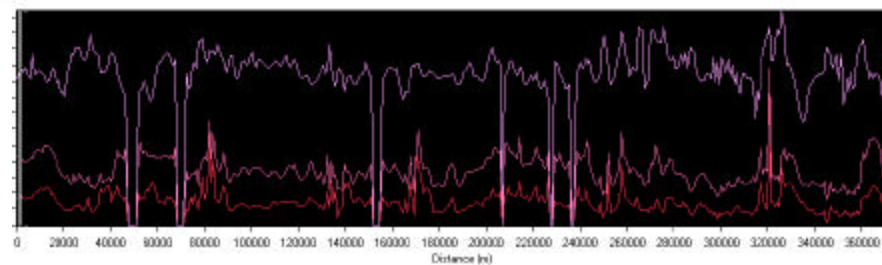
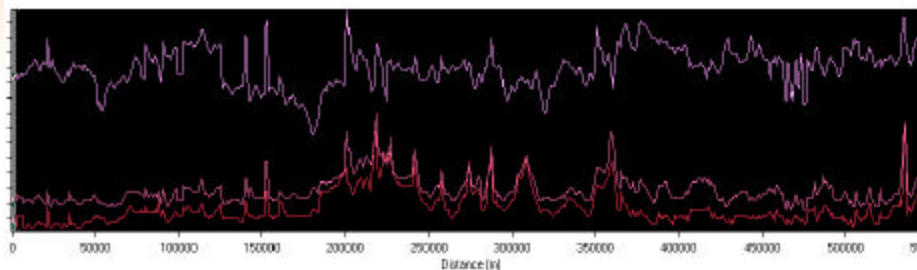
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## BRDF Normalization & Cloud pixel replacement



Corrected

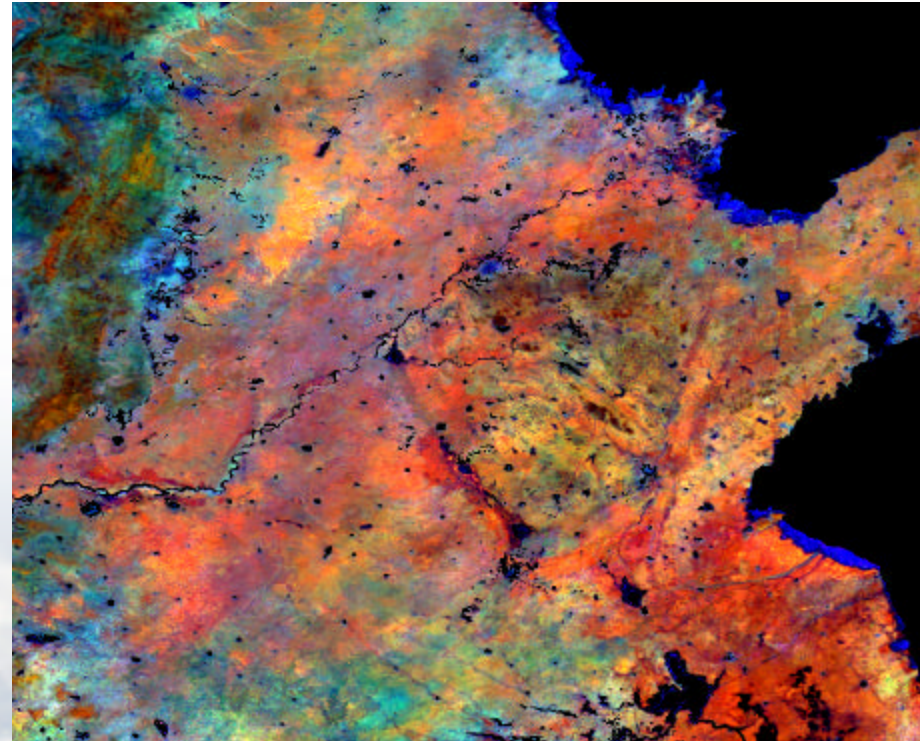
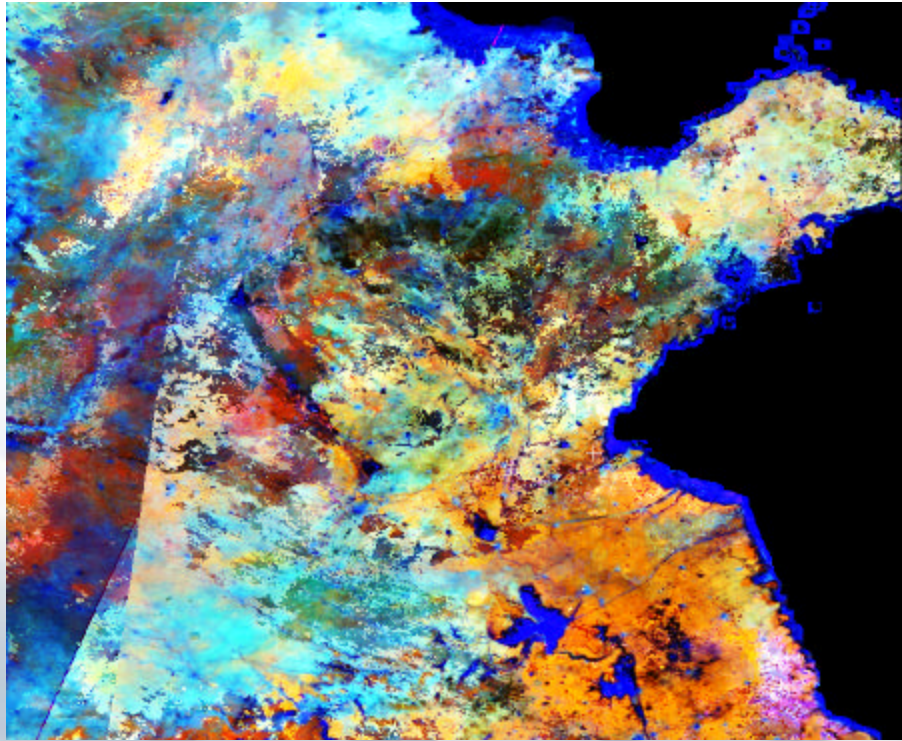






S10

ES10



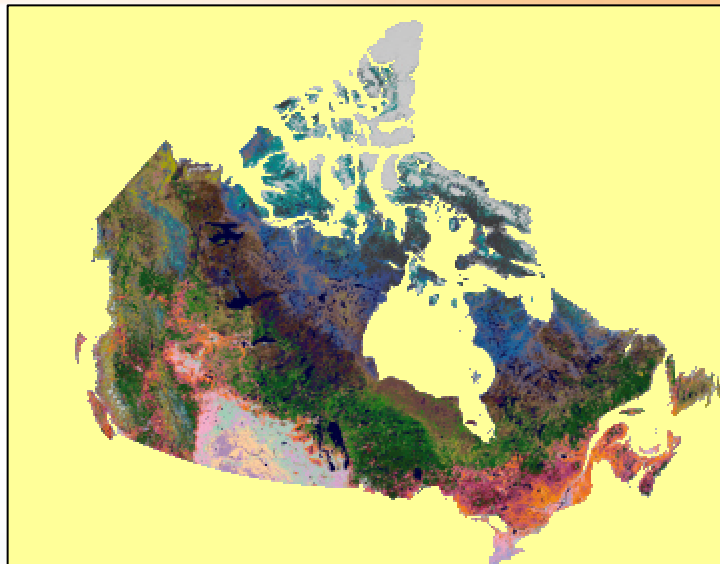
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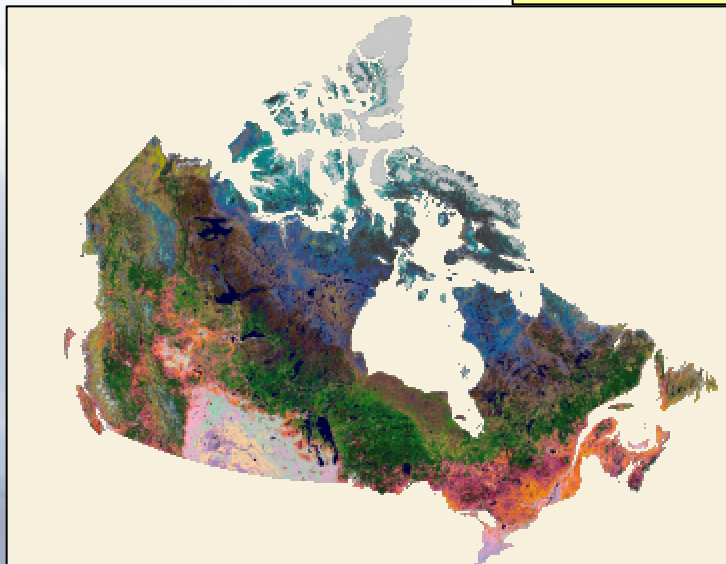


**1995 Land cover**

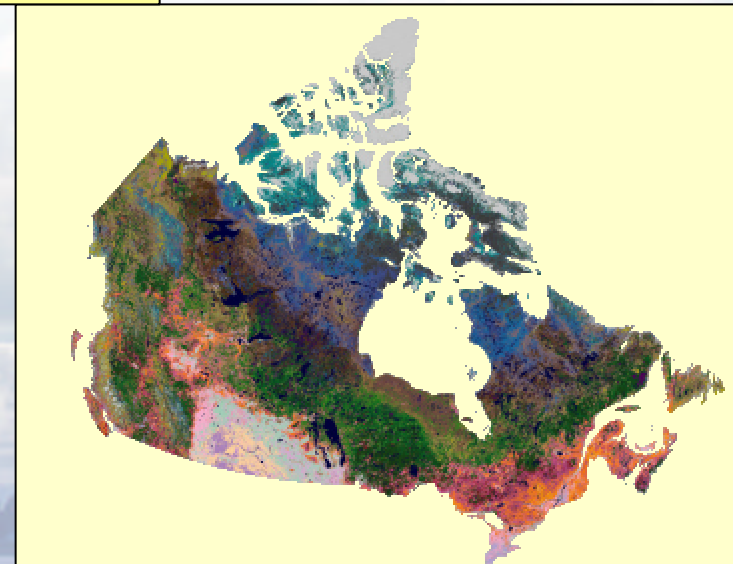


Multi-temporal land  
cover mapping 1990,  
1995 and 2000  
using data from  
NOAA11 and NOAA14

**1990 Land cover**



**2000 Land cover**



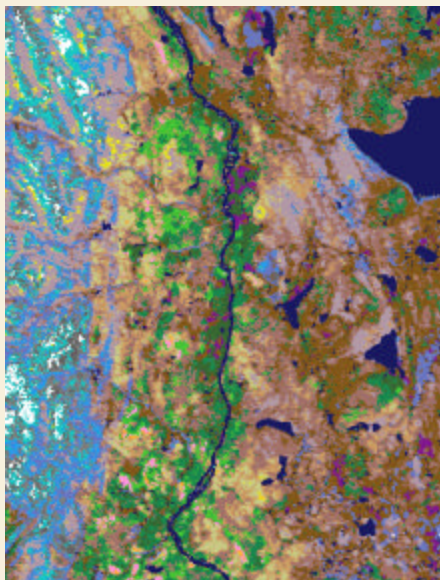




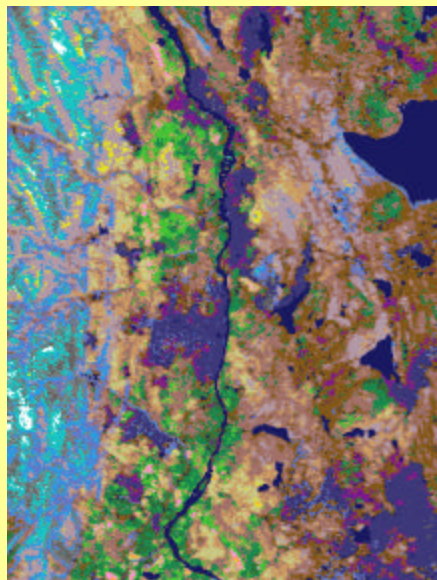
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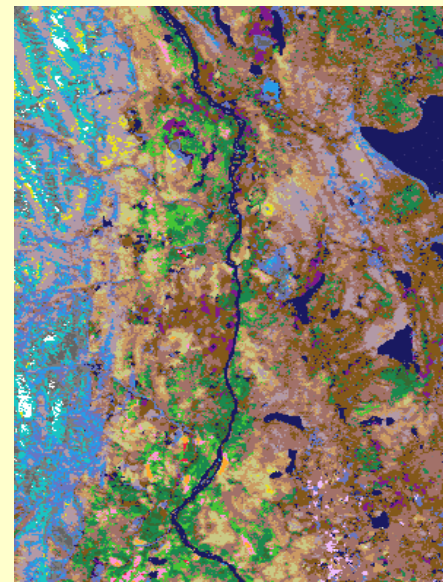
1990



1995



2000



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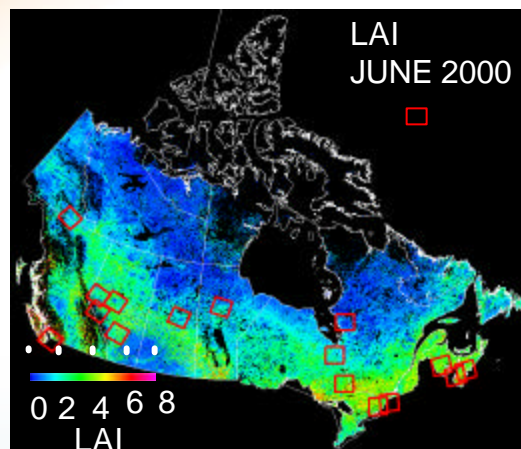
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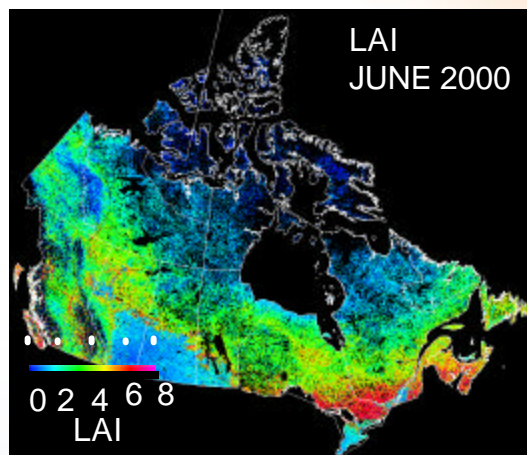


### LAI

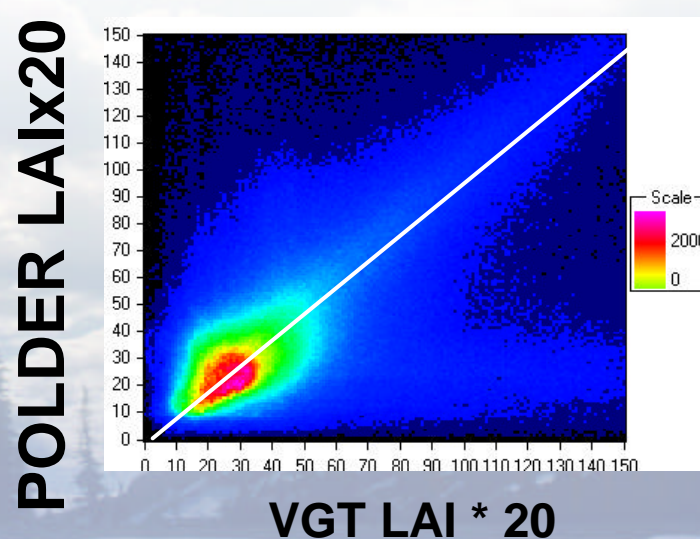
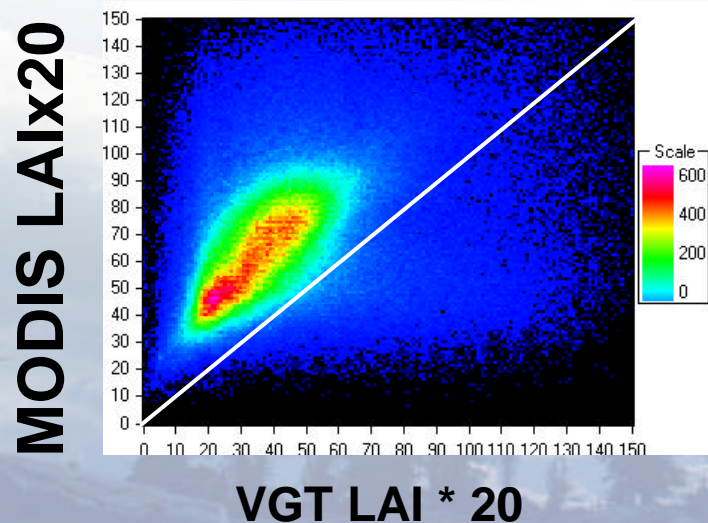
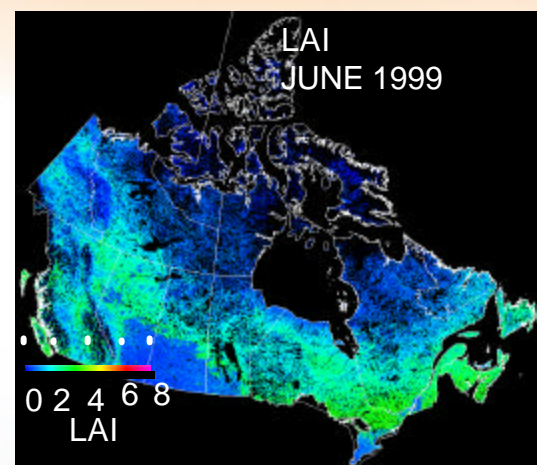
SPOT-Vegetation 10-day 1km



MODIS Monthly 1km



POLDER 10-day (1/18 deg)



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Canada

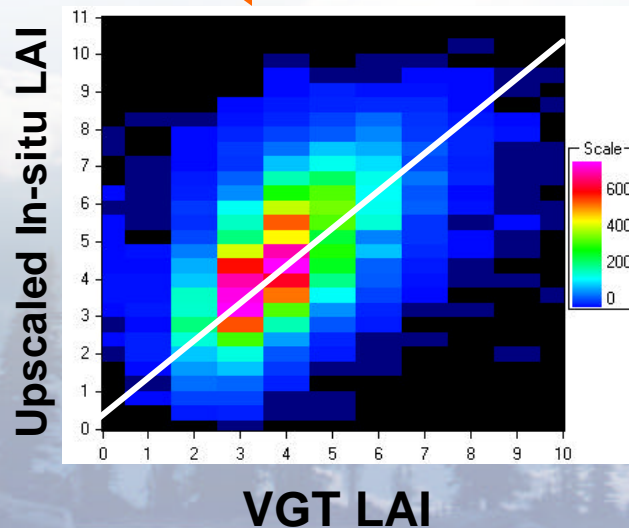
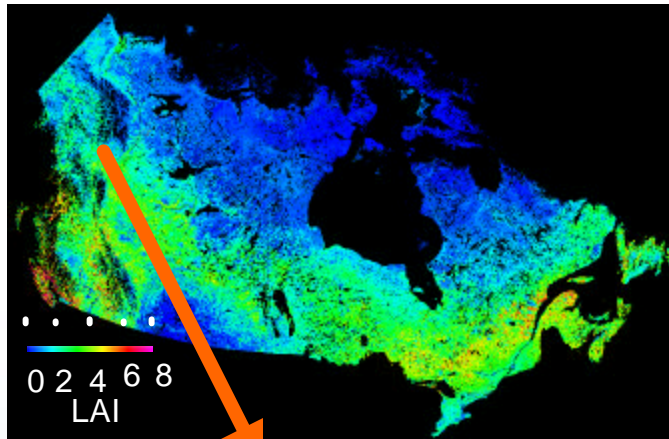
Canada



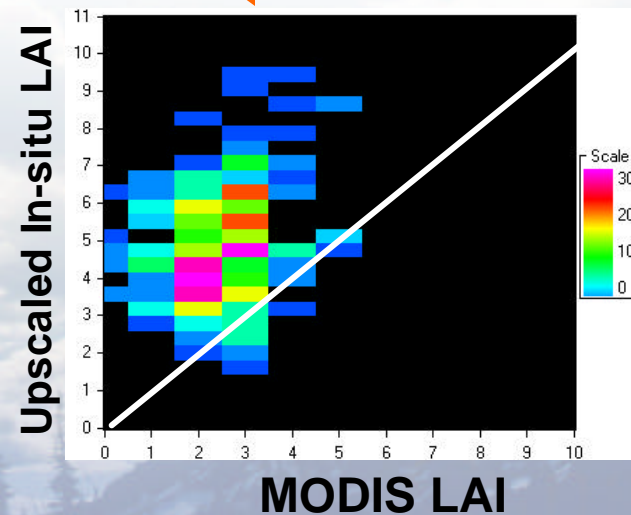
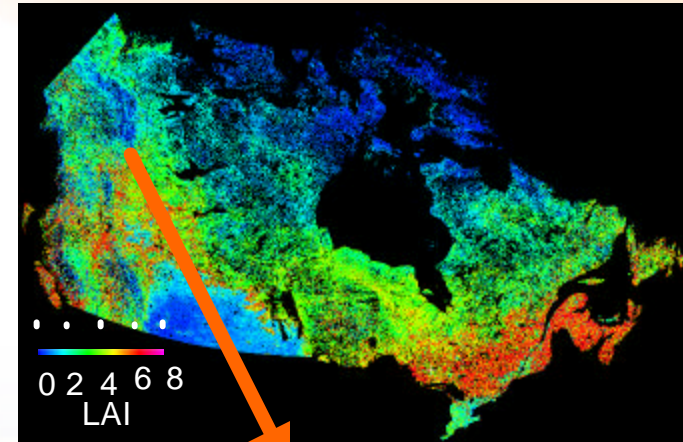
# LAI Validation over Canada Canadian VGT vs US MODIS



SPOT-Vegetation 10-day 1km



MODIS Monthly 1km





## Summary

- Long-term observations sustained over decades are a critical first-step in providing the climate data necessary for scientists, decision makers and stakeholders to make adaptive choices that could improve resilience to climate change and vulnerability, as well as maintain economic vitality.
- CDR's generated from long-term satellite observations have unique characteristics including periodical reprocessing and reanalysis. Thus, processing system need to be constantly improved as the new data correction methodology become available.
- Significant initial steps in generating satellite CDR's over Canada have been accomplished under the ESS Program RCVCC and CSA GRIP project CCEI.
  - AVHRR database that include 9.7 TB is established
  - Core part of AVHRR and VGT processing system is developed
- Today and near future satellite sensors as ENVISAT–MERIS, NPOESS –VIIRS need to be assimilated into CDRs.





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